Advances in Cool Roofing Technologies

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Energy Efficiency in Government Buildings
Hilton Hotel; January 20, 2006; Chicago

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Orthophoto of Sacramento

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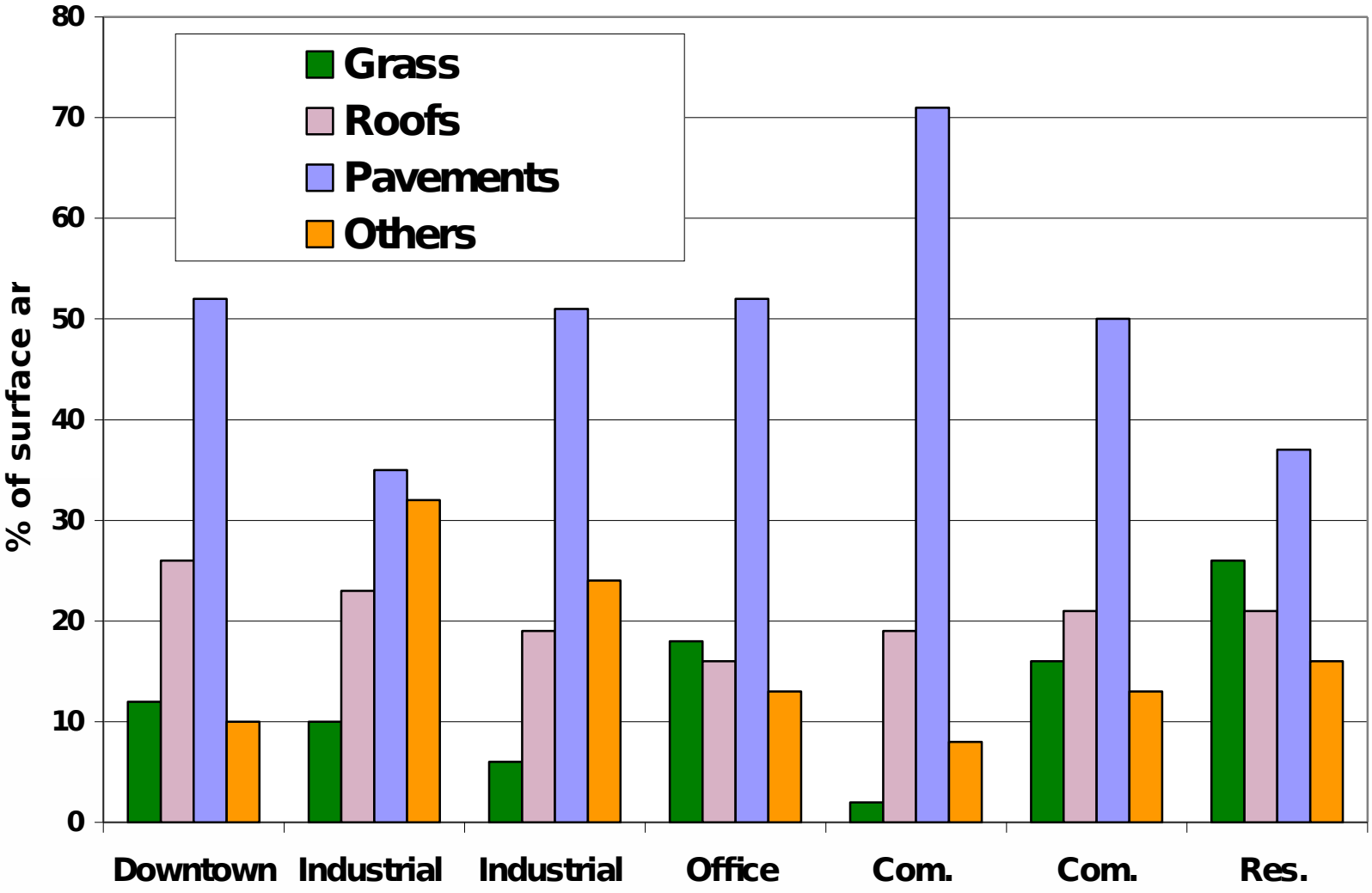
Under the Canopy Fabric of Sacramento, CA



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Direct and Indirect Effects of Light-Colored Surfaces

- **Direct Effect**
  - **Light-colored roofs** reflect solar radiation, reduce air-conditioning use
- **Indirect Effect**
  - Light-colored surfaces in a neighborhood alter surface energy balance; result in lower ambient temperature

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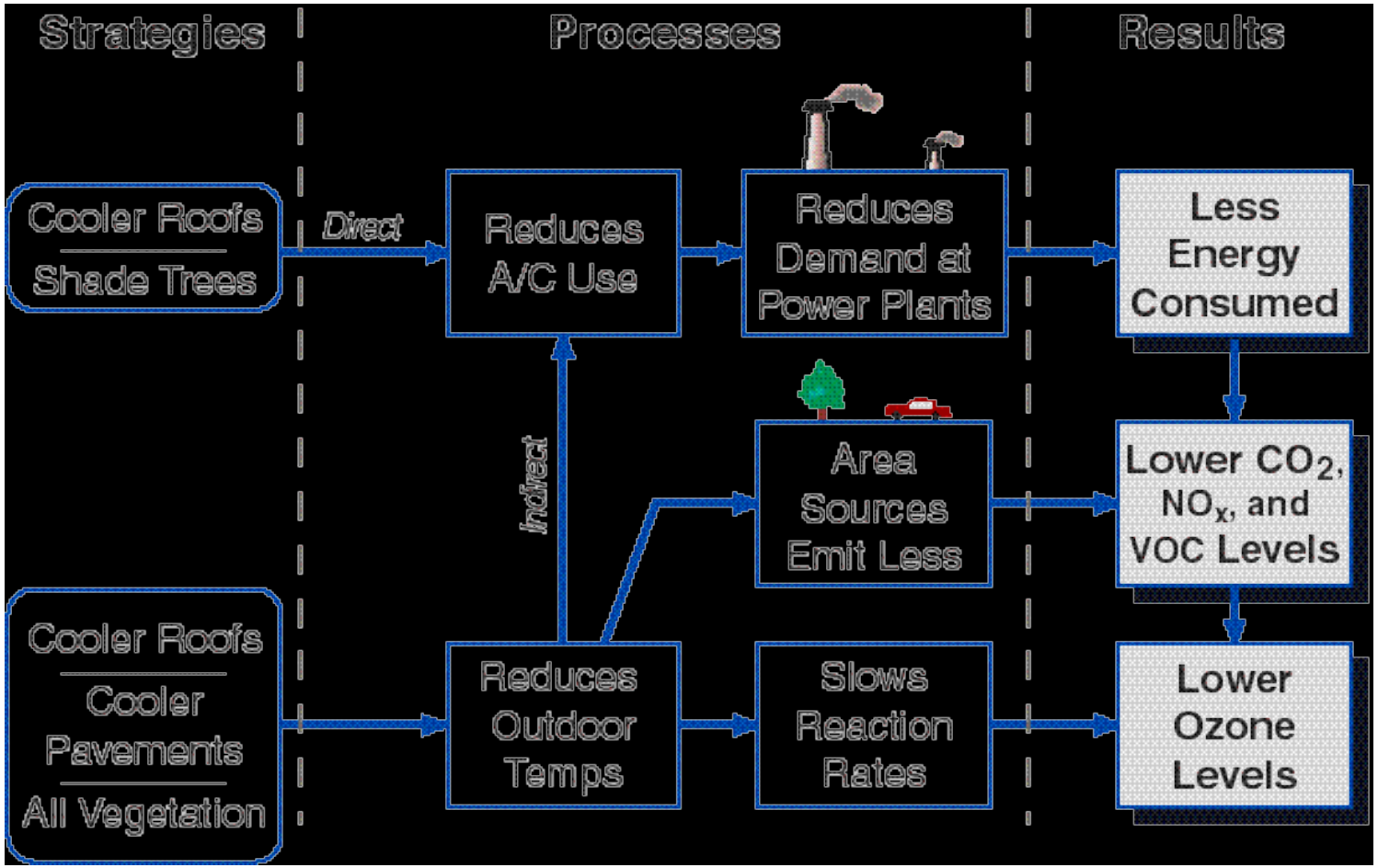
Methodology: Energy and Air-Quality Analysis



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White Roofs: Measured Cooling Savings

- *Sacramento*: 80% in a house; 35% in two school bungalows
- *Florida*: 10%-43% in several houses, average 19%
- *California and Florida:* 5%–20% in several commercial buildings

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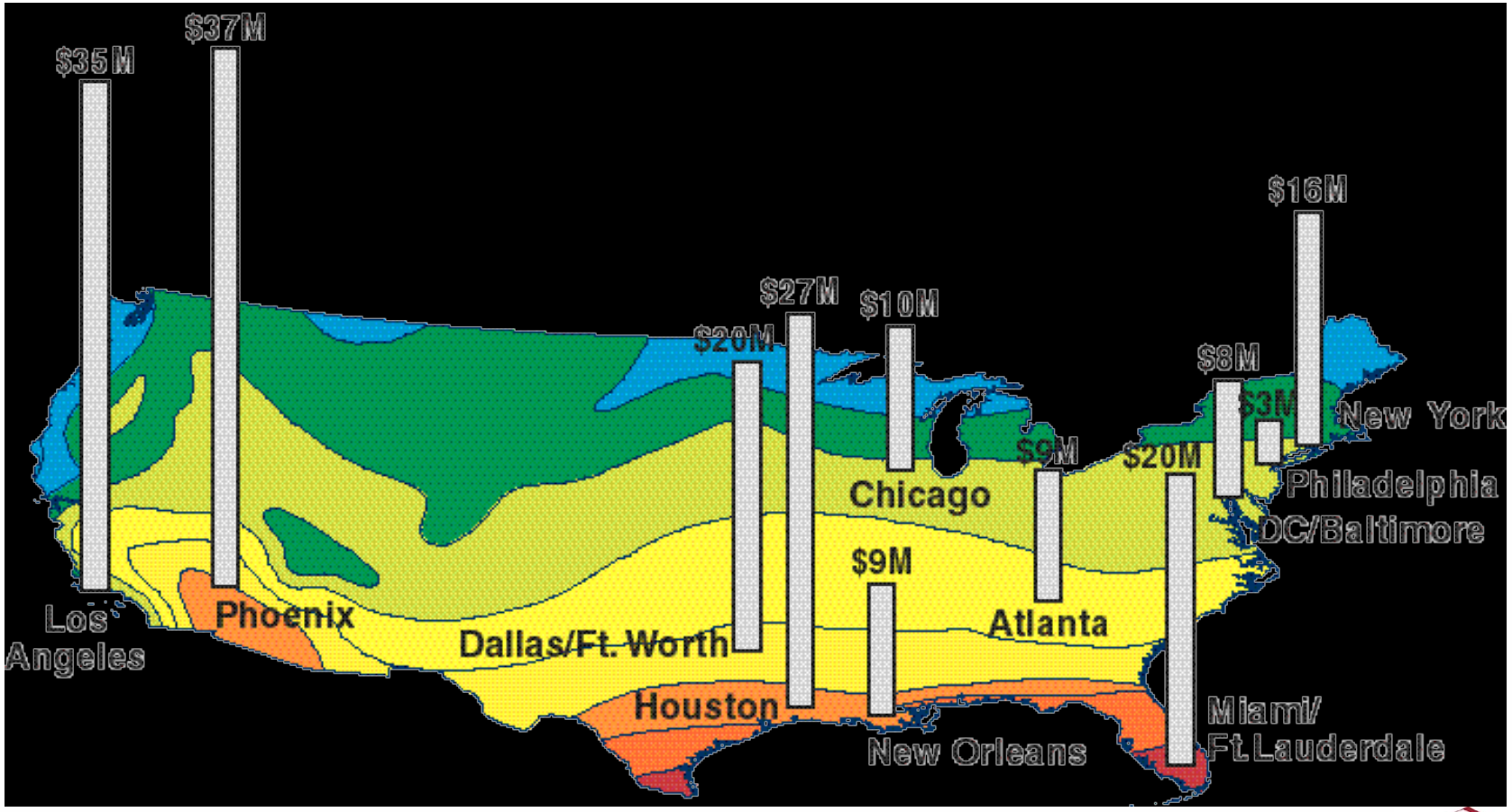
Potential National Savings from Changing Roof Reflectivity Peak Demand Savings in All U.S.



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Cool Roofing Materials Availability Low-Sloped Roofs

- Many materials available
  - coating (white)
  - single-ply membrane (white)
  - painted metal (white, cool colored)

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Cool Roofing Materials Availability High-Sloped Roofs

- Limited but expanding material availability
  - Tile (several maufacturers)
  - Coatings (one manufacturer)
  - Metal (many manufacturers)
  - Shake (only for custom application)
  - Shingles (one manufacturer)
- **Over 70% of high-sloped roofs use hot asphalt shingles**

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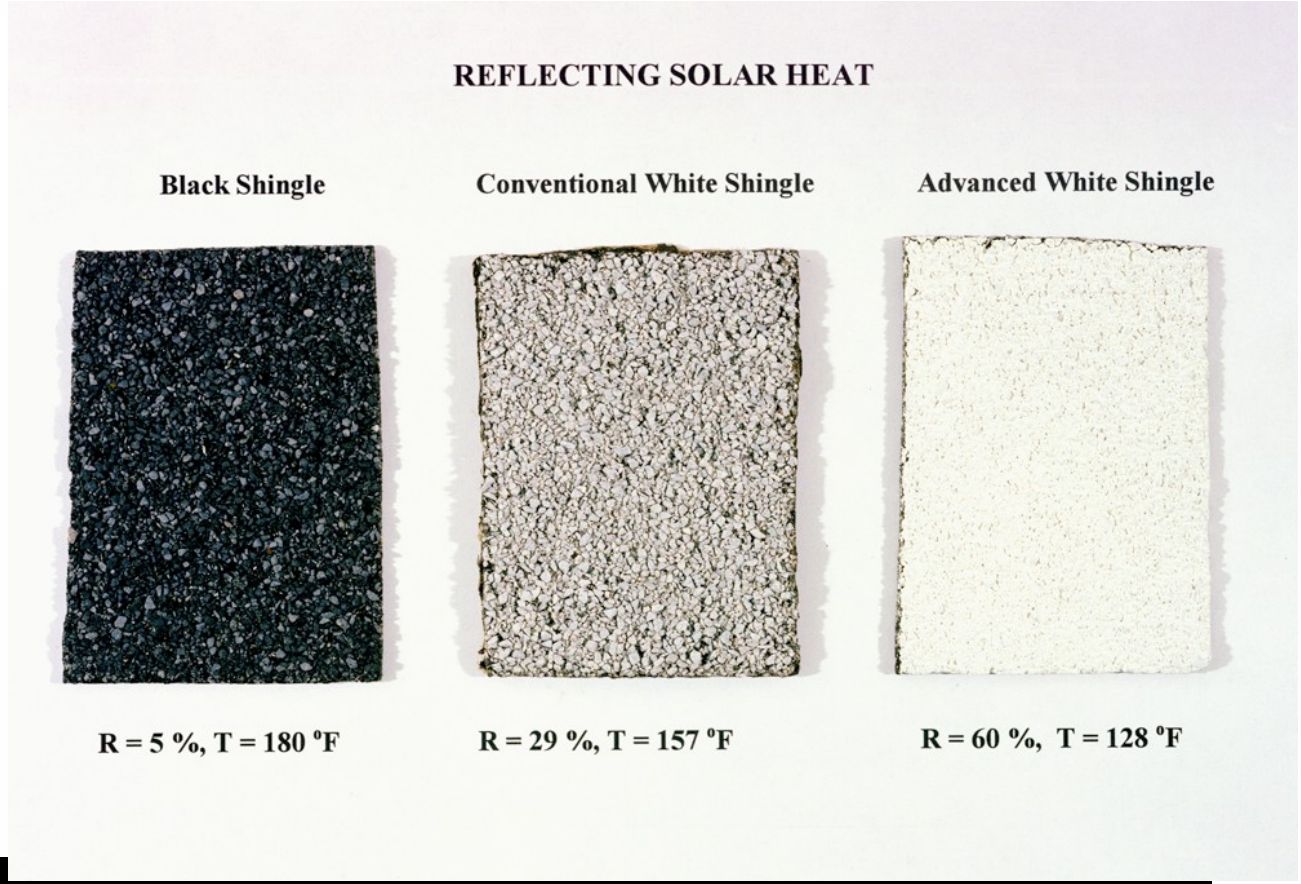
ISP/LBNL Shingle With Whiter Roofing Granules



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White is ‘cool’ in Bermuda

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and in Santorini, Greece

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Cool Roof Technologies

Old

flat, white

pitched, white

New

pitched, cool & colored

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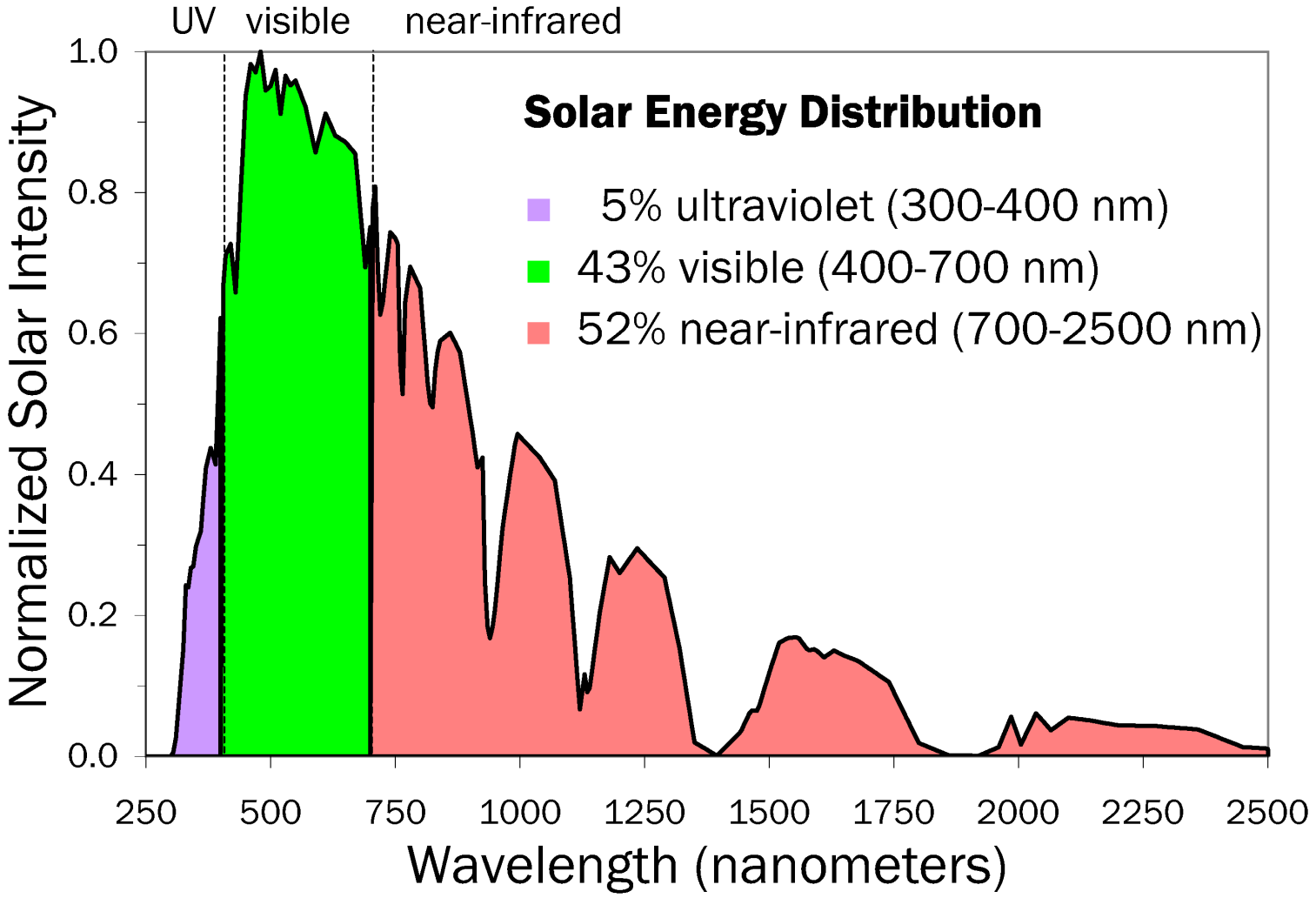
Cool Colors Reflect Invisible Near-Infrared Sunlight



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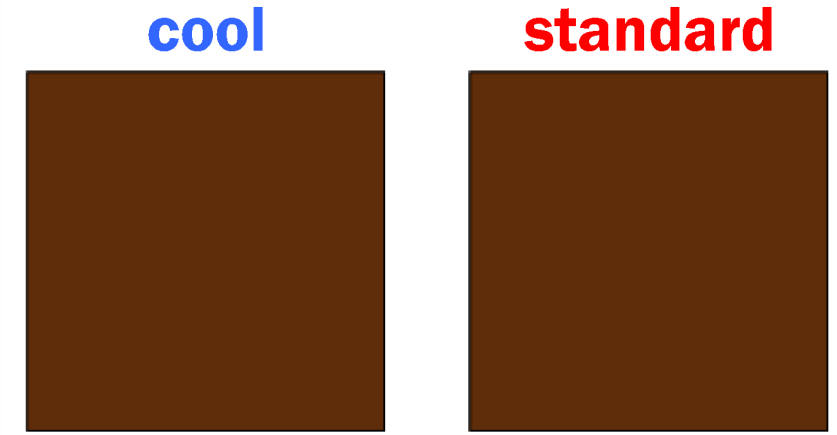
Cool and Standard Brown Metal Roofing Panels

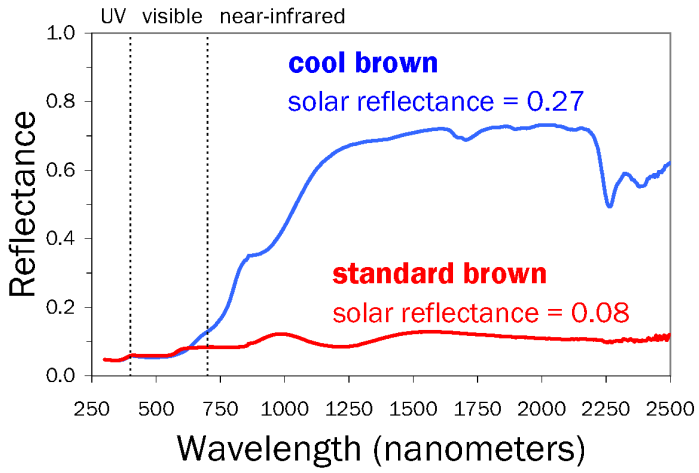
- Solar reflectance ~ 0.2 higher
- Afternoon surface temperature ~ 10ºC lower

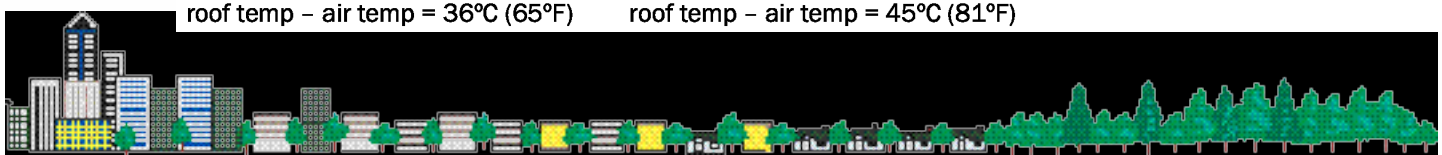
Courtesy BASF Coatings



solar reflectance = 0.27
thermal emittance = 0.85
roof temp – air temp = 36ºC (65ºF)

solar reflectance = 0.08
thermal emittance = 0.85
roof temp – air temp = 45ºC (81ºF)





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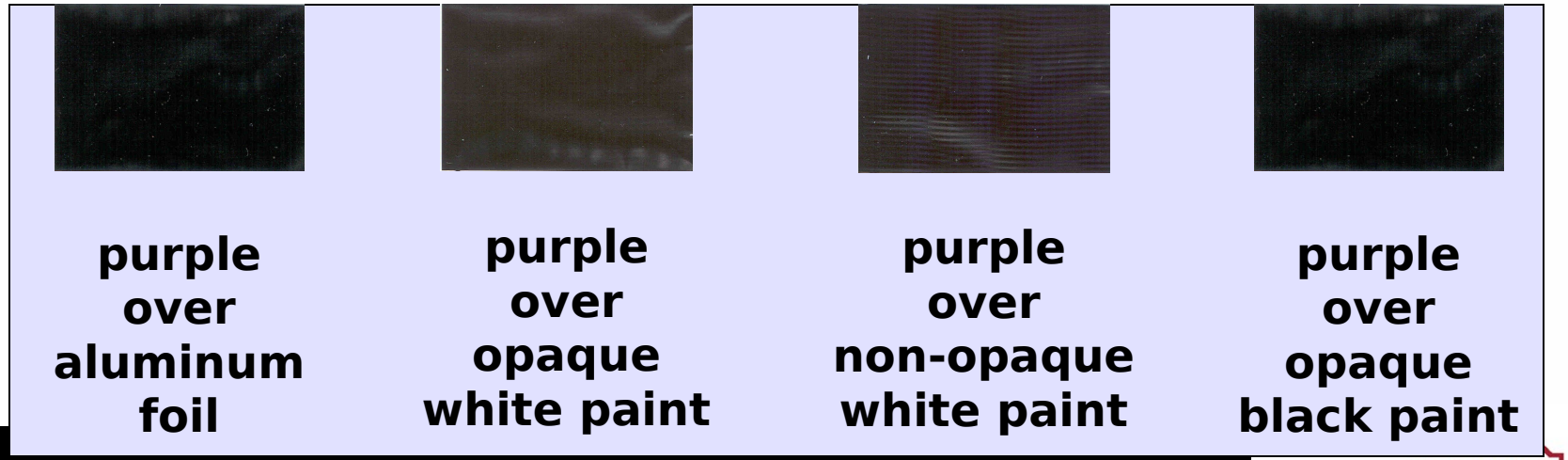
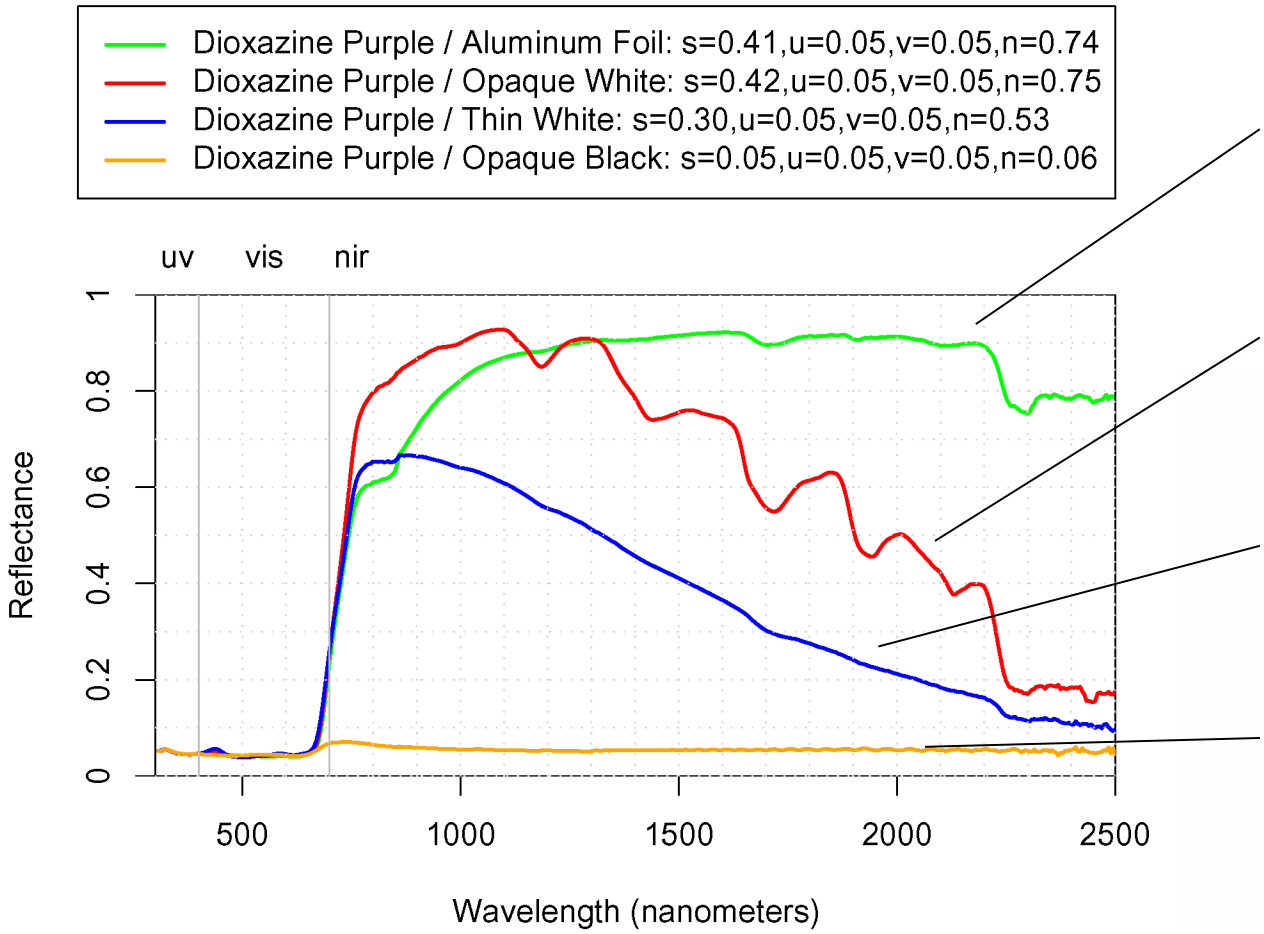
Example: Dioxazine Purple Over Various Undercoats

- Two-layer system
  - top coat: thin layer of dioxazine purple (14-27 µm)
  - undercoat or substrate:
    aluminum foil (~ 25 µm)
    opaque white paint (~1000 µm)
    non-opaque white paint (~ 25 µm)
    opaque black paint (~ 25 µm)


purple over aluminum foil
purple over opaque white paint
purple over non-opaque white paint
purple over opaque black paint

Dioxazine Purple Reflectances



over aluminum
R_{solar} = 0.41

over opaque white
R_{solar} = 0.42

over non-opaque white
R_{solar} = 0.30

over opaque black
R_{solar} = 0.05

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National Labs and Industrial Partnership

- **Program is sponsored by CEC/PIER**
- **ORNL and LBNL are teaming with industry**
- **Broad industrial partnership**

- **Industry partners**
  - **3M (ganules)**
  - **American Roof Tile Coating**
  - **BASF (metal)**
  - **Custom-Bilt Metals**
  - **Elk Manufacturing (shingles)**
  - **Ferro**
  - **GAF (shingles)**
  - **Hanson Roof Tile**
  - **ISP Minerals (ganules)**
  - **MCA (tiles)**
  - **Monier Lifetile (tile)**
  - **Color Company**

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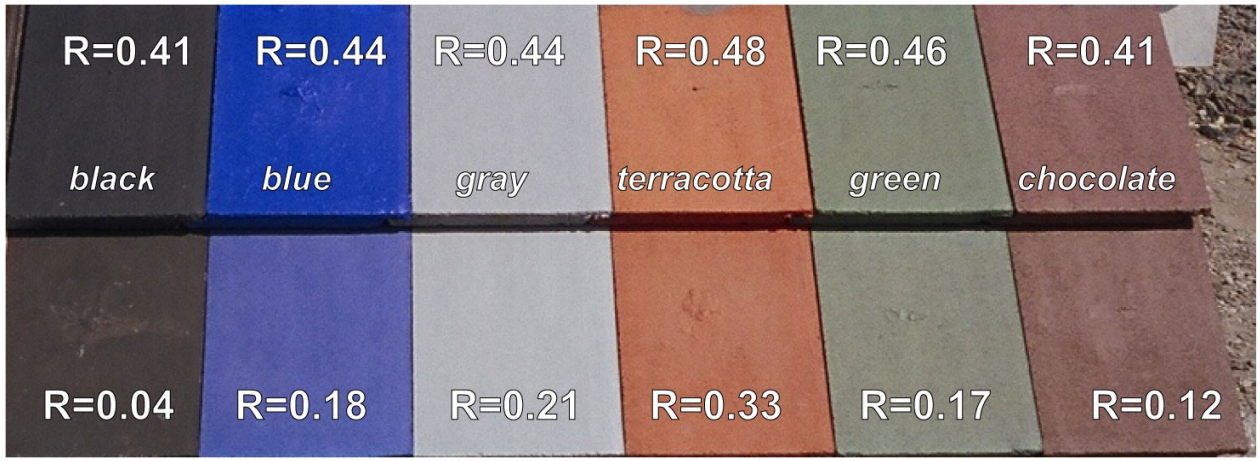
Cool and Standard Color-Matched Concrete Tiles



Courtesy American Rooftile Coatings

cool

standard

ΔR=0.37 ΔR=0.26 ΔR=0.23 ΔR=0.15 ΔR=0.29 ΔR=0.29

- Can increase solar reflectance by up to 0.5
- Gain greatest for dark colors

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Cool Shingles (photographed in sunlight)

standard:

R=0.27

R=0.28

cool: R=0.28

R=0.36

R=0.37

R = solar

ELK
The Premium Choice

Elk Cool Shingle

Cool Metal Roofs

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Cool Colored Clay Tiles

Model	Color	Initial solar reflectance	Solar reflectance after 3 years
Weathered Green Blend		0.43	0.49
Natural Red		0.43	0.38
Brick Red		0.42	0.40
White Buff		0.68	0.56
Tobacco		0.43	0.41

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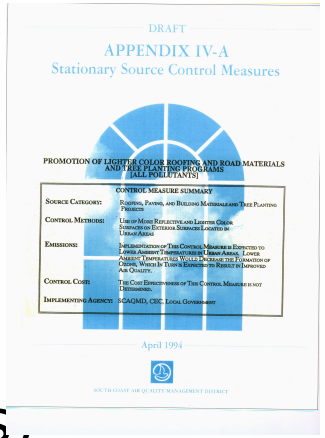
Cool Roofs Standards

- Building standards for reflective roofs
  - American Society of Heating and Air-conditioning Engineers (ASHRAE): New commercial and residential buildings
  - Many state: California, Georgia, Florida, Hawaii, …
- Air quality standards
  - South Coast AQMD
  - S.F. Bay Area AQMD
  - EPA's SIP (State Implementation Plans,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APPENDIX IV-A

Stationary Source Control Measures

PROMOTION OF LIGHTER COLOR ROOFING AND ROAD MATERIALS AND TREE PLANTING PROGRAMS [ALL POLLUTANTS]

CONTROL MEASURE SUMMARY

Source Category:	Roofing, Paving, and Building Materials and Tree Planting Projects
Control Methods:	Use of More Reflective and Lighter Color Surfaces on Exterior Surfaces Located in Urban Areas
Emissions:	Implementation of This Control Measure is Expected to Lower Ambient Temperatures in Urban Areas. Lower Ambient Temperatures Would Decrease the Formation of Ozone, Which Is Turn is Expected to Result in Improved Air Quality.
Control Costs:	The Cost Effectiveness of This Control Measure is not Determined.
Implementing Agency:	SCAQMD, CEC, Local Government

April 1994

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

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White Roofs Programs in California

- One Time CEC Incentive -- $20 Million
  - at $0.15 to $0.20 per square foot
- California utilities incentives
- 2001 to 2005-- **credits** white and cool colored roofs
- 2005 **requires** cool flat roofs
- 2008 may **require** cool roofs for all buildings

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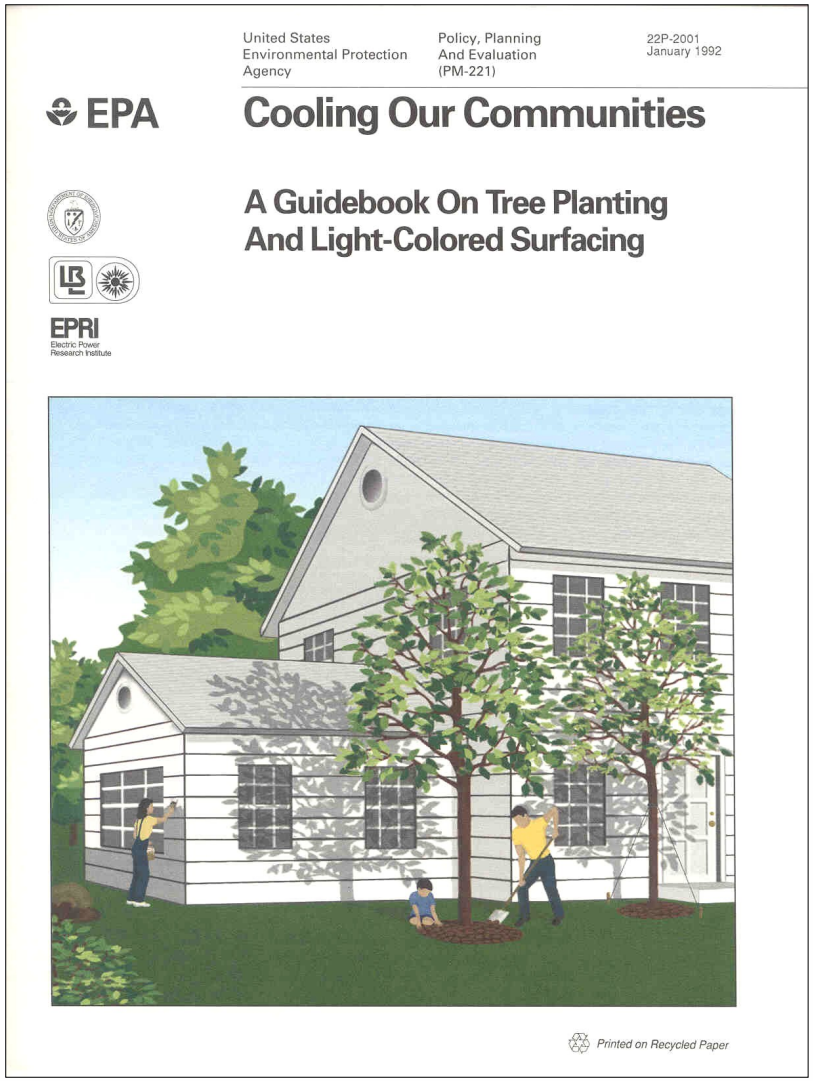
Practical Guidelines



- EPA Guidebook (1992)
  - Good practical information
  - Greatest focus on trees
- EPA is working on a new edition

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